

REMARKS

A substitute specification and abstract are hereby submitted to conform more closely to idiomatic English. No new matter is added. An inadvertent error occurred in the marked up version at page 7 line 9 and is corrected manually.

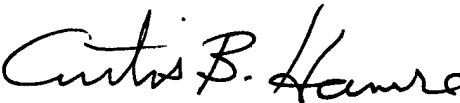
Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of-record, Curtis B. Hamre (Reg. No. 29,165), at (612) 336.4722.

Respectfully submitted,

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SPECIFICATION

TITLE OF THE INVENTION

METHOD FOR FORMING MULTI-LAYER WIRING STRUCTURE

5 BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a method for forming a multi-layer wiring structure on a semiconductor wafer or on a glass substrate.

10 DESCRIPTION OF RELATED ART

In general, a device being formed on a semiconductor wafer or on a glass substrate has a multi-layer wiring structure, with which wiring of lower and upper layers comprising a lower wiring layer and an upper wiring layer which are electrically connected through a so-called via hole.

And ~~However~~, under ~~in~~ such the ~~a~~ multi-layer wiring structure, ~~in which when~~ only an insulating film ~~or layer~~ lies is provided between the upper wiring layer and the lower wiring layer, an unevenness of the lower wiring layer ~~still remains~~ will be present on the surface of the insulating film ~~or layer~~, and it causes ~~cut down~~ breakage will be caused in ~~of~~ the upper wiring layer which is formed on the uneven surface by a CVD method. Therefore, technologies for flattening are normally applied, ~~by in~~ which recesses are filled up with SOG (Spin-On-Glass: silicon oxide film which is formed by coating and baking solution of silicon compound). Among ~~of~~ those, regarding an inorganic SOG including Si-H chemical bonds, it is disclosed in, for example, Japanese

Patent Application Laying-OpenPublication No. Hei 8-316,228
(1996).

The SOG, which is disclosed in Japanese Patent Application
Laying-OpenPublication No. Hei 8-316,228 (1996), ~~however,~~ is the
5 an inorganic SOG including the Si-H chemical bonds.
~~therefore~~Therefore, it ~~shows~~has a high dielectric constant in
comparison with that of an organic SOG, and ~~is easy to cause~~easily
cracks due to heat.

On the other hand, ~~With the an organic SOG,~~ though it does
10 not have ~~such the same problems as that the an inorganic SOG has,~~
~~on the other hand~~However, it is easy to cause a defect which is
called as a "poisoned via" when a resist film is treated by a
so-called an-ashing process by using oxygen gas. Especially
Particularly, in the an organic SOG, an organic group (for example,
15 a methyl group (CH₃)) is bonded to Si, and the atomic radius of
the methyl group is larger than ~~hydrogen-atom~~that of a hydrogen
group of the an inorganic SOG in atomic radius thereof, therefore,
it ~~which~~ causes a serious problem.

This problem will be explained~~Explaining this~~ by referring
20 to Fig. 5 showing a method for forming a multi-layer wiring
structure of the conventional art, ~~first~~First of all, as shown
in Fig. 5 (a), after ~~being formed with a lower wiring layer 101~~
~~thereon,~~is formed on a substrate W, ~~the substrate W is further~~
~~formed with a hillock protection film 102~~ is formed by a CVD method.
25 ~~Further on it,~~ As shown in Fig. 5 (b), the a SOG film 103 is
formed on the hillock protection film 102, and thereafter, as
shown in Fig. 5 (c), an upper wiring layer 104 is formed on the

SOG film 103. Further, a patterned resist layer 105 is provided as shown in Fig. 5 (d), and as shown in Fig. (e), ~~the a~~ via hole (or ~~a~~ through hole) 106 is formed by using the patterned resist layer 105 as a mask through an etching process on the hillock protection film 102, the SOG film 103 and the upper wiring layer 104. Next, as shown in Fig. 5 (f), the patterned resist layer 105 is removed by ~~the an~~ ashing process. Furthermore, as shown in Fig. 5 (g), conductive material 107 ~~of~~ such as aluminum is filled within the via hole 106, thereby electrically connecting between ~~them~~ the wiring layers and constructing ~~the a~~ multi-layer wiring structure.

~~And~~In this method, in a case that ~~where the an~~ organic SOG ~~is applied to used~~, as shown in Fig. 5 (f), the organic components thereof are decomposed ~~or resolved~~ when the resist layer is treated by ~~the an~~ ashing process as shown in Fig. 5 (f), and ~~the a~~ productions such as water, etc., ~~are is~~ stored within the films, thereby causing ~~the a~~ defect 108 being which is called as ~~the a~~ "poisoned via".

Therefore, such a method as shown in Fig. 6, in which the an organic SOG is used and an etching back process is necessarily ~~included therein required~~, ~~is applied~~ has been employed. Namely Specifically, as shown in Fig. 6 (a), after being formed with ~~the a~~ lower wiring layer 101 is formed on a substrate W, the ~~substrate W is further formed with the a~~ hillock protection film 102 is formed by the a CVD method, and ~~further on it is formed~~ the a SOG film 103 is formed thereon. Next, as shown in Fig. 6 (b), ~~the an~~ etching back process is ~~treated used~~ for removing the organic SOG film 103 with an oxygen plasma etc. by such a

predetermined thickness ~~with an oxygen plasma, etc., thereby~~
removing that the organic SOG film 103 is removed to just above
the lower layer wiring layer 101. Thereafter, as shown in Fig.
6 (c), ~~the~~ an upper wiring layer 104 is formed, and as shown
5 in Fig. 6 (d), ~~the~~ a patterned resist layer 105 is formed ~~to cover~~
~~on over~~ the upper wiring layer 104. As shown in Fig. 6 (e), by
~~treating with the~~ conducting an etching process and ~~the~~ a subsequent
ashing process ~~continuously~~, ~~the~~ a via hole 106 is formed ~~on in~~
the hillock protection layer film 102 and the upper wiring layer
10 104, ~~as well as removing and~~ the resist layer is removed., and
~~further~~ Further, as shown in Fig. 6 (f), ~~the~~ conductive material
107 of such as aluminum is filled within the via hole 106, thereby
electrically connecting between the wiring layers them and
constructing ~~the~~ a multi-layer wiring structure.

15 By ~~treating with~~ using such ~~the~~ an etching back process
as shown in Fig. 6, the via hole is ~~not formed in a position~~ an
area where the organic SOG film 103 ~~is located~~ does not exist,
therefore, ~~such the~~ a "poisoned via" will not ~~occur~~ be generated.

However, in recent years, a further ~~promoted~~ microscopic
20 ~~processing~~ demand for miniaturization (for instance, less than
or equal to 0.3 μ m) ~~is~~ has been required, ~~and.~~ if ~~If~~ the wiring
pattern is miniaturized, the thickness of the organic SOG becomes
thick in an area where the wiring patterns ~~are concentrated or~~
~~close to each other~~ is dense, while it ~~is~~ becomes thin in an area
25 where the wiring patterns ~~are coarse or rough~~ is less dense.

~~Under such condition,~~ if the organic SOG film under such
conditions ~~is etching etched~~ backed, ~~there is a disadvantage that~~

even the wiring layer is undesirably also removed by the etching process in an area where the wiring patterns are coarse or rough is less dense.

5 SUMMARY OF THE INVENTION

For dissolving such ~~the disadvantages mentioned in the~~ above, in accordance with the present invention, there is provided a method for forming a multi-layer wiring structure, wherein a lower wiring layer and an upper wiring layer are electrically
10 connected through a via hole, comprising the following steps of:
forming an organic SOG layer directly on said lower wiring layer
or throughon a predetermined film including a hillock protection
layer which is formed on said lower wiring layer in advance; forming
said upper wiring layer on said organic SOG layer without processing
15 using of an etching back process; forming a via hole through an
etching process by using a patterned resist layer provided on
said upper wiring layer as a mask; performing an ashing process
with a plasma by making ions or radicals which is are induced
from oxygen gas as a main reactant, under an atmosphere of pressure
20 ranging from 0.01 Torr to 30.0 Torr; and burying-filling said
via hole with conductive material so as to electrically connect
between-said lower wiring layer and to said upper wiring layer.

By performing ~~the an ashing process with a plasma of by~~
making the ions or radicals which is are induced from the oxygen
25 gas as ~~the a~~ a main reactant under a low pressure ranging from 0.01
to 30.0 Torr, preferably, ~~by performing the ashing process under~~
~~low pressure~~ ranging from 0.01 to 1.2 Torr, it is possible to

suppress the decomposition or resolution of the an organic group
(for example, the a CH₃ group, etc.) which is bonded to an Si
atom of the organic SOG film, and thereby as a result of this,
prevent such thea "poisoned via" and so on will not occur from
5 being generated during the ashing process. Consequently,
Accordingly according to the present invention, it can be
accomplished without such thean etching back process is not
necessary.

A The carbon content of said organic SOG layer lies between is
10 in the range of 5 through to 25 in atomic weight %, more preferably,
between 8 through to 20 in atomic weight %. Here, t The carbon
content is a scale of showing used to determine a ratio of the
an organic group in the an organic SOG, in more detail other words,
it can be theoretically calculated from a reaction amount of the
15 an alkoxysilane compound for preparing a coating - liquid of forming
the an organic SOG, and it is the a ratio of earben the atomic
weight of carbon with respect to the total atomic weight of all
elements.

If the carbon content is less than the range mentioned
20 in the above, since the organic component is too small to thicken
the film or layer, it is easy to cause the thus, cracks will easily
occur therein in addition to, and lose an inherent advantage
thereof, of an organic SOG i.e., a low dielectric constant is lost.
On the other hand, if it the carbon content is too much great,
25 it is not preferable since shortage occurs in a lack of adhesion
occurs between an insulating layer which is provided on an upper
layer.

criticality
of carbon
content

For obtaining ~~the~~ a film having the carbon content mentioned
in the above, it is preferable to use, for example, a coating
liquid containing a compound, which is obtained through hydrolysis
and condensation of at least one being selected from alkoxysilane
5 compounds in an organic solvent under existence of an acid
~~eatalysiscatalyst~~, said alkoxysilane compound being expressed
by a general equation, $R_nSi(OR^1)_{4-n}$, where R is an alkyl group
~~or an aryl group of having a carbon number of from 1 to 4~~ or
~~aryl group~~, R^1 is an alkyl group of having a carbon number of
10 ~~from 1 to 4~~, and n is an integer of 1 or 2.

or aryl group
CBH

~~As an~~ The following are examples of the alkoxysilane
compound which is expressed by the above general equation, ~~the~~
~~followings can be listed:~~

(a) in a case that where $n=1$, monoalkyltrialkoxysilane including:

15 monomethyltrimethoxysilane, monomethyltriethoxysilane,
monomethyltripropoxysilane, monoethyltrimethoxysilane,
monoethyltriethoxysilane, monoethyltripropoxysilane,
monopropyltrimethoxysilane, monopropyltriethoxysilane, etc.,
and monophenyltrialkoxysilane including:
20 monophenyltrimethoxysilane, monophenyltriethoxysilane, etc.

(b) in a case that where $n=2$, dialkyldialkoxysilane including:

dimethyldimethoxysilane, dimethyldiethoxysilane,
dimethyldipropoxysilane, diethyldimethoxysilane,
dimethyldiethoxysilane, diethyldipropoxysilane,
25 dipropyldimethoxysilane, dipropyldiethoxysilane,
dipropyldipropoxysilane, etc., and diphenyldialkoxy-silane
including: diphenyldimethoxy-silane, diphenyldiethoxy-silane,

etc. It is necessary to use at least one kind from (a) and (b).

If desired, as another compounds which can be condensed with the (a) and (b), ~~in case that n=0 of the compound, namely,~~ it is also effective to use a case where n=0 of the compound which
5 is expressed by the above general equation, namely, (c) tetraalkoxysilane, ~~—~~: ~~—~~ including tetramethoxysilane, tetraethoxysilane, tetrapropoxysilane, tetrabutoxysilane, etc.

Among those, the compounds preferable from a practical
view point are tetramethoxysilane, tetraethoxysilane,
10 monomethyltrimethoxysilane, monomethyltriethoxysilane, dimethyldimethoxysilane, and dimethyldiethoxysilane.

It is possible to use only one of those alkoxy silane compounds, or two or more being selected from them in combination.

~~Concretely Specifically, when combining combination of two~~
15 ~~kinds of the (a) and (bc), or when combining three kinds of combination of the (a), (b) and (c), also when only one kind of the and (a) alone are preferable.~~

Regarding the mol ratio of reaction in the case that where
~~the two kinds of the (a) and (c) are combined, upon 1 mol of (c)~~
20 ~~tetraalkoxysilane is reacted with 0.5 - 4.0 mol, more preferably 1.0 - 2.0 mol of (a) monoalkyltrialkoxysilane, more preferably, by reacting 1.0 - 2.0 mol of (a), and thereby obtaining a desirable coating -liquid containing a product obtained through hydrolysis and condensation thereof is used.~~

25 ~~Further, when combining three kinds of the~~ In the case where
(a), (b) and (c) are combined, ~~upon 1 mol of (b)~~
dialkyldialkoxysilane are is reacted with 0.5 - 4.0 mol, more

preferably 1.0 - 3.0 mol of (c) tetraalkoxysilane and 0.5 - 4
mol of the (a) monoalkyltrialkoxysilane, more preferably, by
reacting 1.0 - 3.0 mol of the (c) and 0.5 - 4.0 mol, more preferably
0.5 - 3.0 mol of the (a) monoalkyltrialkoxysilane, thereby
5 obtaining and a desirable coating liquid containing a product
obtained through hydrolysis and condensation thereof is used.

Further, in the case of only the (a)
monoalkyltrialkoxysilane alone, it is likely to obtain a ladder
type of product obtained through the hydrolysis and condensation
10 easily has a ladder type structure, and the such a ladder type
product of that ladder type is preferable to form a fine film.

The hydrolysate obtained with the hydrolysis can be
one which is completely hydrolyzed or which is partially hydrolyzed.
A The degree of the hydrolysis can be adjusted by an amount of
15 water to be added, therefore, and the amount of water to be added
is adjusted appropriately depending on the characteristics of
the organic SOG intended layer to be formed. In general, it is
desired that upon total amount 1 mol of alkoxysilane, which is
used to prepare the coating liquid, the water is reacted at a
20 ratio of 1.0 - 10.0 mol, more preferably at a ratio of 1.5 - 8.0
mol thereof with respect to 1 mol of alkoxysilane which is used
to prepare the coating liquid. If the ratio of water is too
much lower than this range, the degree of hydrolysis comes down
to becomes low and it becomes difficult to form a film,
25 therefore undesirable. Further, if the ratio of water is
too much higher than this range, it is easy to occur gelation
or gel formation, therefore, not preferable since easily occurs,

~~which causes it results~~ bad stability ~~for the purpose of~~ in preservation thereof.

Further, ~~with as for~~ the acidic catalyst, ~~both each of~~ organic acid ~~or and~~ inorganic acid, which have been commonly used in the conventional art, can be used. As the organic acid, organic carboxylic acid ~~can be listed, including such as~~ acetic acid, propionic acid, butyric acid, ~~etc can be used~~. As the inorganic acid, ~~can be listed, such as~~ hydrochloric acid, nitric acid, sulfuric acid, phosphoric acid, etc. can be used.

In this case, the acidic catalyst is added into the coating liquid in such a manner that ~~concentration~~ the concentration of acid lies within a range of 1 - 1,000 ppm, more preferably 5 - 500 ppm, or is added in a ~~form-state of an~~ acidic water-aqueous solution obtained by mixing the acid and water to be added, and thereby ~~obtaining hydrolysis~~ is performed.

The hydrolysis ~~completes the reaction thereof~~ is normally completed within 5 - 100 hours. Further, the reaction can be completed in a short reaction time ~~by heating it, at a temperature from room temperature up to 80°C and by droppadding the an acid~~ catalyst water aqueous solution of acidic catalyst into an organic solvent containing the an alkoxysilane compound ~~for the reaction thereof~~ so as to be reacted at a temperature heated from room temperature up to 80°C. The alkoxysilane compound which is hydrolyzed in this manner causes a condensation reaction, and ~~as a result thereof, thereby it obtains~~ an ability to be formed in a form of a film or layer is obtained.

As the organic solvent, various organic solvents which

have been commonly used in the conventional art, can be used.
For ~~e~~ Examples of such solvents, ~~there can be listed~~ are: monohydric
alcohol, including ~~such as~~ methyl alcohol, ethyl alcohol, propyl
alcohol, butyl alcohol, etc.; polyhydric alcohol, including ~~such~~
5 ~~as~~ ethylene glycol, diethylene glycol, propylene glycol, etc.;
a polyhydric alcohol derivative, including ~~such as~~ ethylene glycol
monomethyl ether, ethylene glycol monoethyl ether, ethylene
glycol monopropyl ether, ethylene glycol monobutyl ether,
propylene glycol monomethyl ether, propylene glycol monoethyl
10 ether, propylene glycol monopropyl ether, propylene glycol
monobutyl ether, ethylene glycol monomethyl ether acetate,
ethylene glycol monoethyl ether acetate, propylene glycol
monomethyl ether acetate, propylene glycol monoethyl ether
acetate, etc.; and a fatty acid, including ~~such an~~ acetic acid,
15 a propionic acid, etc. ~~These~~ These respective organic solvents
can be used not only ~~one by one~~ individually, but also used in
combination of two or more kinds thereof, ~~selecting more than~~
~~2 from them~~. ~~With~~ As for the amount of ~~them to be used~~ the organic
solvent, the organic solvent is used at a ratio of 10 - 30 mol
20 ~~of them is used upon~~ with respect to 1 mol of alkoxysilane.

Further, in accordance with the method for forming a
~~multi~~ multi-layer wiring structure of the present invention,
~~preferable good results~~ can be obtained with respect to the a SOG
film which is formed from a coating - liquid including polysilazane.
25 ~~With such the polysilazane, it~~ It is preferable that it such
polysilazane lies in has a weight-average molecular weight (Mw)
in polystyrene conversion of a range 1500 - 5000 in average

molecular weight (M_w) of polystyrene conversion, which is measured by gel permeation chromatography (GPC), in particular within a range more preferably 1,700 - 3,000, which is measured by gel permeation chromatography (GPC). Furthermore, it is preferable
5 that the dispersion degree (M_w/M_n) lies within a range from 1 to 4, since it shows good stability for preservation.

In particular, since the polysilazane has an active organic group inside (hydrogen atom which is bonded to a nitrogen atom and a silicon atom) within, therefore, it is easy to cause
10 bridge-building or chemical cross-linking bridge formation easily occurs and thereby to an increase of viscosity, or gelation is caused. For preventing this, it is preferable to use polysilazane in which be processed with hexamethyle disilazane to replace a part of the active hydrogen is replaced with a trimethylsilyl
15 group by processing with hexamethyl disilazane, since it has good stability for preservation.

As the an organic solvent for dissolving the polysilazane, from view points of fire fighting safety, dryness and stability for preservation, it is preferable that it is to use a solvent
20 having low hygroscopic character hygroscopicity. As Examples of such a compound solvent, there can be listed, such as are: dialkylether of an alkyl group of having a carbon number of more than 4, xylene, cyclohexane, dimethylcyclohexane, ethylcyclohexane, p-menthane, decalin, 2,2,5-trimethylhexane,
25 dipentene, decane, isononane, octane, etc. Among of these these, dialkylether of an alkyl group having a carbon number of more than 4 is preferable, and in particular, dibutylether is preferable.

~~These~~ These ~~respective-organic~~ solvents can be used not only one
by one individually, but also used in combination of two or more
kinds thereof, ~~selecting more than 2 from them.~~

The coating liquid for forming the an organic SOG film,
5 or the coating liquid containing the polysilazane, in accordance
with the present invention, is preferable to have the
above-mentioned hydrolysate of ~~the above-mentioned~~ alkoxy silane
or the polysilazane at a concentration of 5 - 40 weight% of ~~solid~~
body, more preferably 10 - 25 weight% with respect to solids,
10 so as to achieve a stability for preservation and to thicken a
film to be formed.

Further, in the method for forming the an organic SOG film,
the above-mentioned coating liquid is ~~coated~~ applied onto a
substrate ~~of such as~~ a semiconductor substrate, a glass substrate,
15 a metal substrate, a ceramic substrate, ~~etc.,~~ by means of a
so-called a spinner method, a roll coating method, an immersion
coating method, a spray method, a screen printing method, a brush
painting method, etc., ~~and it is dried to scatter or evaporate~~
the solvent therein, and thereby the a coating film is formed.
20 Then, it is baked at ~~the a~~ temperature of 250 - 500 °C, and thereby
~~the an~~ organic SOG film ~~being is~~ formed.

~~On the other hand, with~~ Also, in the method for forming
the a SOG film which is formed from the a coating liquid containing
the polysilazane, ~~it is also formed in a similar manner to that~~
25 ~~mentioned in the above~~ the same steps are employed.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 (a) shows a graph of an infrared absorption spectrum when-being-treated-byin a case where an ashing process is performed for a predetermined time period-under an atmospheric pressure of 1.2 Torr by using a plasma ashing apparatus of leaf-and-a single
5 wafer down-stream type-or-model, and Fig. 1 (b) shows a graph of an infrared absorption spectrum when-being-treated-byin a case where an-the ashing process is performed for a time period-of 30 seconds under a predetermined atmospheric pressure by using the same apparatus;

10 Fig. 2 (a) shows a graph of an infrared absorption spectrum when-being-treated-byin a case where an ashing process is performed for a predetermined time period-under an atmospheric pressure of 1.0 Torr by using a plasma ashing apparatus of leaf-and-a single
15 wafer down-stream model-type, and Fig. 2 (b) shows a graph of an infrared absorption spectrum when-being-treated-byin a case where an-the ashing process is performed for a time period-of 30 seconds under a predetermined atmospheric pressure by using the same apparatus;

Fig. 3 (a) shows a graph of an infrared absorption spectrum when-being-treated-byin a case where an ashing process is performed for a predetermined time period-under an atmospheric pressure of 0.8 Torr by using a plasma ashing apparatus of leaf-and-a single
20 wafer down-stream type, and Fig. 3 (b) shows a graph of an infrared absorption spectrum when-being-treated-byin a case where the-an
25 ashing process is performed for a time period-of 20 seconds under a predetermined atmospheric pressure by using the same apparatus;

Fig. 4 (a) shows a graph of an infrared absorption spectrum

when being treated by in a case where an ashing process is performed
for a predetermined time period under an atmospheric pressure
of 0.01 Torr by using a plasma ashing apparatus of leaf and a single
wafer down-stream type, and Fig. 14 (b) shows a graph of an infrared
5 absorption spectrum when being treated by in a case where an the
ashing process is performed for a time period of 30 seconds under
a predetermined atmospheric pressure by using the same apparatus;

Figs. 5 (a) through Fig. 5 (g) show processes for flattening
in accordance with a the conventional art; and

10 Figs. 6 (a) through Fig. 6 (g) show processes of etching
back in accordance with a the conventional art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, detailed explanations of the embodiments
15 according to the present invention will be given by referring
to the attached drawings.

(Example 1)

Preparation of Coating Liquid

~~Tetramethoxysilane of 246 g (1.62 mol) of~~
20 tetramethoxysilane ~~and monomethyltriethoxysilane of 220 g (1.62~~
mol) of monomethyltrimethoxysilane are dissolved and ~~mixed into~~
propyleneglycolmonopropylether of 635 g (5.38 mol) of
propyleneglycolmonopropylether, and mixed. Next, a mixture of
~~purified water of 194 g (10.78 mol) of deionized water and nitric~~
25 ~~acid of 24 ppm~~ of nitric acid is ~~droppadded in it~~ thereinto and
stirred slowly for about 5 hours. Thereafter, it is left standing
still for 5 days ~~in at~~ at room temperature so as to obtain a solution;

at ~~15 weight % of having~~ a solids state concentration of 15 weight % thereof.

As ~~a coating liquid, the~~ This solution mentioned in the above is ~~coated~~ applied onto the ~~a~~ hillock protection film covering
5 a lower wiring layer formed on the substrate, thereby forming an organic SOG film. The carbon content in the organic SOG film which is obtained by ~~a~~ the following equation, ~~and~~ is 9.4 atomic weight %:

$$C / (CH_3SiO_{3/2} + SiO_2) \times 100$$

10 Then, ~~on this organic SOG film is formed~~ an upper wiring layer is formed on this organic SOG film without performing the an etching back process, and further ~~the~~ a via hole is formed with an etching process by using ~~the~~ a patterned resist layer as the a mask. Thereafter, with use of a plasma ashing apparatus of
15 ~~a leaf type and a single wafer~~ down-stream type, an ashing process is ~~treated~~ performed so as to remove the resist film layer, by making ions or radicals which ~~is~~ are induced from oxygen gas as a main reactant, under an atmospheric ~~of~~ pressure of 1.2 Torr. Thereafter, ~~the via hole is buried~~ filled with a conductive material
20 so as to electrically connect ~~between the lower layer wiring layer~~ and to the upper layer wiring layer.

Fig. 1 (a) shows the infrared absorption spectrums which are obtained by ~~changing~~ setting the time period of the above-mentioned ashing process, ~~sequentially, from a curve at~~
25 ~~a top thereof, i.e., to~~ 60 seconds, 45 seconds, 30 seconds, 15 seconds and no processing, respectively. From this drawing, it is apparent that Si-C bonding bonds ~~is~~ are not broken, in the

case of the present invention.

On the other hand, Fig. 1 (b) shows the infrared absorption spectrums which are obtained through the ashing process for 30 seconds by using the same plasma ashing apparatus, by changing
5 setting the pressure of the above-mentioned ashing process, i.e.,
to 50 Torr, 40 Torr, 35 Torr and 30 Torr, respectively from a curve
at a top thereof, sequentially, though the same condition as
mentioned in the above is applied until forming the via hole by
treating the etching process, while the time is fixed to 30 seconds.

10 From this drawing, it is apparent that the Si-C bonding bonds
is are broken and OH bonds are generated if the pressure during
of the ashing process is high, and OH bonding is caused.

(Example 2)

Preparation of Coating Liquid

15 Tetramethoxysilane of 304.2 g (2 mol) of
tetramethoxysilane, monomethyltrimethoxysilane of 272.4 g (2 mol)
of monomethyltrimethoxysilane and dimethyldimethoxysilane 120.2
g (1 mol) of dimethyldimethoxysilane are dissolved and mixed into
isopropylalcohol of 608.6 g (8.21 mol) of isopropylalcohol, and
20 mixed. Next, a mixture of purified water of 288.0 g (16 mol)
of deionized water and nitric acid of 40 ppm of nitric acid is
dropped in it thereinto and stirred slowly for about 5 hours.
Thereafter, it is left standing still for 5 days in a room
temperature so as to obtain a solution, at 16 weight % of having
25 a solids state concentration thereof of 16 weight %.

As a coating liquid, the This solution mentioned in the
above is coated applied onto the hillock protection film covering

a lower wiring layer formed on the substrate, thereby forming an organic SOG film. The carbon content in the organic SOG film which is obtained by a the following equation, ~~and~~ is 14.6 atomic weight %:

5
$$3C/[(CH_3)_2SiO_{2/2} + CH_3SiO_{3/2} + SiO_2] \times 100$$

Then, ~~on this organic SOG film is formed~~ an upper wiring layer is formed on this organic SOG film without conducting the an etching back process ~~in the same manner as in the above~~, and ~~further the~~ a via hole is formed with an etching process by using
10 ~~the a~~ a patterned resist layer as ~~the a~~ a mask. Thereafter, using ~~the a~~ a plasma ashing apparatus of a ~~leaf type and a single wafer~~ down-stream type, an ~~ashing process is treated~~ ashing process is conducted so as to remove the resist ~~film~~ layer, by making ions or radicals which ~~is~~ are induced from oxygen gas as a main reactant, under an
15 ~~atmosphere~~ ic of pressure of 1.0 Torr. Thereafter, the via hole is ~~buried~~ filled with a conductive ~~body~~ material so as to electrically connect ~~between the lower layer wiring layer and~~ to the upper layer wiring layer.

Fig. 2 (a) shows the infrared absorption spectrums which
20 are obtained by ~~changing~~ setting the time ~~period~~ of the above-mentioned ashing process, ~~sequentially, from a curve at a top thereof, i.e., to~~ 60 seconds, 45 seconds, 30 seconds, 15 seconds and no processing, respectively. From this drawing, it is apparent that the Si-C bonding bonds ~~is~~ are not broken, in
25 the case of the present invention.

On the other hand, Fig. 2 (b) shows the infrared absorption spectrums which are obtained ~~through the ashing process for 30~~

~~seconds by using the same plasma ashing apparatus, by changing~~
~~setting the pressure of the above-mentioned ashing process to,~~
~~i.e., 50 Torr, 40 Torr, 35 Torr and 30 Torr, respectively from~~
~~a curve at a top thereof, sequentially, though the same condition~~
5 ~~as mentioned above is applied until forming the via hole by treating~~
~~the etching process, while the time is fixed to 30 seconds.~~ From
this drawing, it is apparent that the Si-C bonding bonds is are
broken and OH bonds are generated if the pressure during of the
ashing process becomes high, ~~and OH bonding is caused.~~

10 (Example 3)

Preparation of Coating Liquid

~~A solution at 10 weight % in the solid state concentration~~
~~is used as the coating liquid, in which a A ladder type product~~
~~obtained from monomethyltriethoxysilane through the hydrolysis~~
15 ~~and the condensation under the existence of an acid catalyst~~
~~is dissolved into ethanol, and a solution having a~~
~~solids concentration of 10 weight % is obtained.~~ This coating
~~liquid solution is coated applied onto thea hillock protection~~
~~film covering a lower wiring layer on the substrate, thereby forming~~
20 ~~an organic SOG film. Further, t~~The carbon content in the organic
SOG film which is obtained by a the following equation, and is
17.9 atomic weight %:

$$C / [(CH_3)SiO_{3/2}] \times 100$$

Then, ~~on this organic SOG film is formed an upper wiring~~
25 ~~layer is formed on this organic SOG film without conducting the~~
~~an etching back process in the same manner as in the above, and~~
~~further thea via hole is formed with an etching process by using~~

the ~~a~~ patterned resist layer as ~~the a~~ mask. Thereafter, using
the ~~a~~ plasma ashing apparatus of a leaf ~~type and a~~ single wafer
down-stream type, an ashing process is ~~treated~~ conducted so as
to remove the resist ~~film~~ layer, by making ions or radicals which
5 ~~is~~ are induced from oxygen gas as a main reactant, under an
atmospheric ~~ef~~ pressure of 0.8 Torr. Thereafter, the via hole
is ~~buried~~ filled with a conductive ~~body~~ material so as to
electrically connect between the lower wiring layer ~~wiring and to~~
the upper wiring layer ~~wiring~~.

10 Fig. 3 (a) shows the infrared absorption spectrums which
are obtained by ~~changing~~ setting the time ~~period~~ of the
above-mentioned ashing process, ~~sequentially, from a curve at~~
~~a top thereof, i.e.,~~ to 60 seconds, 45 seconds, 30 seconds, 15
seconds and no processing, respectively. From this drawing, it
15 is apparent that the Si-C bonding bonds ~~is~~ are not broken, in
the case of the present invention.

On the other hand, Fig. 3 (b) shows the infrared absorption
spectrums which are obtained ~~through the ashing process for 20~~
~~seconds by using the same plasma ashing apparatus, by changing~~
20 setting the pressure of the above-mentioned ashing process, i.e.,
to 40 Torr, 35 Torr, 30 Torr and 0.01 Torr, respectively ~~from~~
~~a curve at a top thereof, sequentially, though the same condition~~
~~as mentioned above is applied until forming the via hole by treating~~
~~the etching process, while the time is fixed to 20 seconds~~. From
25 this drawing, it is apparent that the Si-C bonding bonds ~~is~~ are
broken and OH bonds are generated if the pressure during of the
ashing process becomes high, ~~and OH bonding is caused~~.

(Example 4)

Preparation of Coating Liquid

A ~~solution at 20 weight % in the solid state concentration~~
~~is obtained by dissolving into dibutylether a~~ A product
5 ~~(weight-average molecular weight = 2200, number-average molecular~~
~~weight = 950, dispersion = 2.3) which is obtained by adding and~~
~~reacting hexamethyldivilazane-hexamethyldisilazane upon with~~
~~polysilazane (average molecular weight=2200, average molecular~~
~~number=950, dispersion=2.3), is dissolved into dibutylether, and~~
10 ~~a solution having a solids concentration of 20 weight % is obtained,~~
~~in which the polysilazane is composed from ingredients, i.e.,~~
~~such as dichlorosilane-dichlorosilane and ammonia according to~~
~~an ordinal common method. This coating liquid solution is coated~~
~~applied onto thea~~ hillock protection film covering a lower wiring
15 layer on the substrate, thereby forming a SOG film.

Then, ~~on this SOG film is formed an~~ upper wiring layer
~~is formed on this SOG film without conducting the an~~ etching back
~~process in the same manner as in the above, and further thea~~ via
hole is formed with an etching process by using the a patterned
20 resist layer as the a mask. Thereafter, using the a plasma ashing
apparatus of a ~~leaf type and a single wafer~~ down-stream type, an
ashing process is ~~treated conducted~~ so as to remove the resist
~~film layer~~, by making ions or radicals which ~~is are~~ induced from
oxygen gas as a main reactant, for 30 seconds, under an atmosphere
25 atmospheric of pressure of 0.01 Torr. Thereafter, the via hole
is ~~buried filled~~ with a conductive body material so as to
electrically connect ~~between the lower wiring layer wiring and~~

to the upper wiring layer ~~wiring~~.

Fig. 4 (a) shows the infrared absorption spectrum after ~~treating with the~~ ashing process is conducted, ~~and. from~~ From this drawing, it is apparent that the N-H bonding bonds is ~~are~~
5 not broken, in the case of the present invention.

On the other hand, Fig. 4 (b) shows the infrared absorption spectrum which ~~are~~ is obtained through the ~~ashing process for~~ 30 seconds by using the same plasma-ashing apparatus, under by
10 setting the atmospheric pressure of the above-mentioned ashing process at to 35 Torr, ~~though the same condition as mentioned above~~ is applied until forming the via hole by treating the etching process. From this drawing, it is apparent that the N-H bonding bonds is ~~are~~ broken and OH bonds are generated if the pressure during of the ashing process becomes high, ~~and OH bonding is caused~~.

15 As is fully explained in the above, in accordance with the present invention, ~~decomposition or resolution of the an~~ organic group (for example, the a methyl group (CH₃), etc.) bonded to the an Si atom of the organic SOG film can be suppressed, and as a result, the phenomenon called known as a "poisoned via" will
20 not occur during the ashing process of the resist film layer. Consequently, ~~it can be completed or achieved without the etching back process~~ can be omitted, and, thereby simplification of the processes can be simplified obtained. Further, the ~~similar same~~ effect can be obtained achieved from with respect to the SOG film
25 which is formed from ~~the a~~ coating liquid containing the polysilazane.

Moreover, since the etching back process can be omitted ~~it~~

~~can be completed or achieved without the etching back process,~~
there is no possibility that the lower wiring layer ~~wiring is~~
removed during the etching back process, and thereby being able
it becomes possible to cope with form a further miniaturized
5 pattern.

ABSTRACT OF THE DISCLOSURE

For suppressing decomposition of an organic group (for example, a CH₃ group) ~~during ashing process,~~ which is bonded to an Si atom
5 of an organic SOG film ~~or layer for use in a flattening process~~
at the time of an ashing process, there is provided a method
~~comprises comprising the following steps of:~~ forming an organic
SOG layer directly on a lower wiring layer or ~~through~~ on a
predetermined film including a hillock protection layer which
10 is formed on saidthe lower wiring layer in advance; forming said
an upper wiring layer on saidthe organic SOG layer without
processing using ofan etching back process; forming a via hole
through an etching process by using a patterned resist layer
provided on ~~saidthe~~ upper wiring layer as a mask; performing
15 an ashing process with a plasma by making ions or radicals which
isare induced from oxygen gas as a main reactant, under an
~~atmosphere ofic~~ pressure ranging from 0.01 Torr to 30.0 Torr;
and ~~burying-filling~~ said via hole with a conductive material so
as to electrically connect ~~between-saidthe~~ lower wiring layer
20 ~~and to saidthe~~ upper wiring layer.